# Pilot Ergonomics Program
# Public Works Center, San Diego

2000

Chief of Naval Operations
*Corporate Ergonomics Program*
*Pilot Program Evaluation*

CNO (N454)

# Executive Summary

Work Related Musculoskeletal Disorders (WMSD) are occupational injuries affecting the muscles, tendons, nerves, ligaments, joints, cartilage and spinal discs and they accounted for $4.3M of the Navy's worker compensation in 1998. Federal Employee Compensation Act data indicated 44 percent of the cumulative compensation cost is due to musculoskeletal injuries and back injuries totaling $100M.

The Chief of Naval Operations (CNO-N454) chose Public Works (PWC) San Diego to demonstrate an effective ergonomics program would improve worker health and safety, quality of life, increase worker productivity, and reduce cost. The two-year pilot program at PWC San Diego reported the following results:

- 74% reduction in the annual cost of WMSDs
- 55% reduction in WMSD incidents
- 70% reduction in lost workdays due to WMSDs
- 14,745 hour reduction in annual labor hours resulting in a total cost reduction of $219,115
- $250,657 net savings
- $3.42 to $1 savings to investment ratio.

In addition to a one-time $25,000 program grant from CNO (N454), PWC San Diego received training and program management oversight and assistance. All ergonomic worksite evaluations, ergonomic interventions, equipment, tools, and worksite reengineering expenses were paid for by PWC San Diego.

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# 1. Introduction

## Introduction

Navy worksites, like those in private industry, need to control recognized workplace hazards. The most common hazard is ergonomic-related. Ergonomics is the science of designing the worksite, machines and work tasks with human capabilities and limitations in mind. In other words, fit the workplace to the worker. When ergonomics is effectively incorporated into worksite design and processes, workers tend to be more comfortable, productive and sustain fewer injuries.

Risk factors that can result in ergonomic injuries and illnesses include: repetitive, forceful or prolonged exertions; heavy lifting; pushing, pulling or carrying of unwieldy objects; fixed or awkward work postures, contact stress; hand, arm or whole-body vibration, temperature extremes and poor lighting.

## Purpose and Goals of the Report

The purpose of this report is to demonstrate that a well-organized ergonomics program, with enthusiastic command support, is a valuable tool in controlling WMSDs. This report demonstrates that the pilot ergonomics program at PWC San Diego:

- Improved worker health, safety and quality of life
- Increased productivity of PWC personnel
- Reduced injury and illness costs

This report will provide information necessary to demonstrate the value of an effective ergonomics program. Unless otherwise specified, data presented in this report pertains to PWC San Diego only.

## The U.S. Navy Corporate Ergonomics Program

Over $250M is spent annually by the US Navy on civilian work related injuries and illnesses. An estimated 44% of these injuries, or $100M[1], are considered injuries related to poor ergonomic conditions. Indirect costs, such as, reduced productivity, low moral, retraining and long-term disability benefits are not normally considered and would raise this ergonomic injury costs substantially. The Navy considers a proactive approach of identifying ergonomic risk factors and taking action will keep workers healthy and also drive down compensation costs.

After careful study of several existing corporate ergonomics programs, the Chief of Naval Operations (N454) determined a three pronged approach was necessary to implement an effective ergonomics program. This three pronged approach required coordination of the following entities:

- **Command Safety office .** The safety office administered and coordinated the ergonomic program including data collection and evaluation of proposed ergonomic interventions.

- **Human Resource Office (HRO).** The HRO provided detailed tracking and monitoring information necessary to evaluate the effectiveness of the ergonomic program. Data collected included Federal Employee Compensation Act (FECA) and work related injury and illness compensation costs.

- **Medical Department**. The Medical Department identified and documented work related ergonomic injuries and illnesses.

The ergonomic program's primary message is pain is not a necessary consequence of work. Musculoskeletal and neural injury associated with poor ergonomic conditions are avoided through proper training combined with effective ergonomic interventions.

## Origin of the Navy Corporate Ergonomic Program

In August 1995, CNO implemented a pilot program entitled the Navy Corporate Ergonomic Program (NCEP) to determine the elements of a comprehensive Navy-wide ergonomics program. The development of the NCEP was based on successful ergonomic efforts in the private sector, Naval Air Systems Command (NAVAIR), and Naval Facilities Engineering Command (NAVFAC). Plans called for the NCEP to be implemented using the following 4-stage process:

[1] OSH SYS CD, 1997

- **Stage One – Ergonomics Strategy**. This stage laid the groundwork for the NCEP, and consisted of four major sections: management support, the ergonomics program, up-front training, and measures of effectiveness.

- **Stage Two – Model Efforts**. This stage laid out a plan to evaluate ergonomic practices at model activities. It employed the ergonomics strategy established in Stage One. This stage consisted of five major sections: identify command/activities for the model effort, conduct a pre-intervention survey at the model activities, implement the ergonomics effort at the model site, create measurements of effectiveness of ergonomic interventions, and perform data analysis.

- **Stage Three – Process Modification**. This stage examined the data obtained and processes used at the model sites. It determined the results of the model effort and briefed the results to appropriate commands. This stage modified the ergonomics program accordingly to improve effectiveness. The three sections of this stage were: develop lessons learned, develop and brief results, and modify the process/program using the results learned from the model efforts.

- **Stage Four – Navy Implementation**. This stage assumes the model efforts were successful as demonstrated by improved worker health, cost reduction, and Navy-wide support of ergonomics. This stage would consist of six sections: promulgation of revised ergonomics guidance, institutionalization of developed training, implementation of measurement methods, incorporation of process oversight, process advertisement (Navy awareness enhancement), and measurement, continued analysis, and process/product correction as needed.

## Goals of the Navy Corporate Ergonomics Program

- Reduce the incident/severity rates of Navy personnel and improve their quality of life

- Increase productivity for Navy personnel

- Reduce Workers' Compensation (WC) costs due to work related to musculoskeletal disorders (WMSD)

  A. WMSDs are defined as:

  -All injuries affecting the muscles, tendons, nerves, ligaments, joints, cartilage and spinal discs that are a result of normal work duties.

  -WMSDs most often occur in the following muscle groups:

1. Upper extremity (rotator cuff strain, elbow or wrist tendinitis, carpal tunnel syndrome)

2. Trunk (neck and back strain)

3. Lower extremity (knee cap strain, patella tendinitis, plantar fasciitis)

CNO (N454) selected an NCEP Program Manager (PM) responsible for coordinating and monitoring the progress and status of the NCEP. A physical therapist (PT) was contracted to conduct training and assist pilot sites with initiating and executing pilot programs. The PM and the PT formed the NCEP Management Team. The management team reported directly to CNO (N454).

## Selection of PWC San Diego as a pilot site

Once the decision to establish a series of pilot sites for the NCEP was made, a list of potential pilot sites was made. Pilot sites were selected based upon the following criteria:

- Must have a diversity of work functions with potentially high associated ergonomic risks

- Must have a mature and well-functioning safety program

- Command personnel must be eager to participate

- Site must not be on a Base Realignment and Closure list

Based on this list of qualifications, PWC San Diego was selected as a representative site for the NCEP pilot program. The Navy Occupational Safety and Health (NAVOSH) Quality Council (QC) approved the selection on 19 December 1995.

CNO (N454) provided training and assisted the pilot sites in implementing the local pilot programs. CNO (N454) provided PWC San Diego with a one-time $25,000 grant to cover program start-up expenses. After implementation of the pilot program, PWC San Diego assumed all of the pilot program's operating expenses.

The pilot program at PWC San Diego was conducted during fiscal years 1997 and 1998. Results of the program are based on data for those years unless otherwise stated. Fiscal year 1996 was used to establish a baseline for comparison purposes.

# 2. Discussion

## Ergonomics Enhances Mission Readiness

Any tool that enhances worker performance, productivity and associated work processes enhances mission readiness. The PWC San Diego Mission Statement stated: "Our mission is to provide quality, responsive, cost-effective and environmentally sound solutions to meet our fleet and shore customers' public works needs.". PWC San Diego's ergonomics pilot program enabled them to accomplish their mission with fewer lost workdays, reduced WMSD incidents, and fewer labor hours. Added benefits of the pilot program were an increase in worker job satisfaction and quality of life and increased confidence that the command's prime concern was their safety and welfare.

## Targeted Trades

Choosing worksite processes for this program began with directing limited resources toward those trades that would benefit the most from ergonomic training and intervention. Preliminary discomfort surveys, analysis of worker compensation related costs and lost workday rates were all used as tools in identifying these trades, known collectively as the "targeted trades". These trades represented the group of workers with the highest ergonomic risk for 1996.

The targeted trades identified were ranked according to documented worker compensation costs due to ergonomic injury. All of the targeted trades received ergonomic training specific to their work processes to increased employee awareness of ergonomic hazards. This training often resulted in changes to work processes not documented in this study.

The following matrix describes the ranking of the targeted trades from FY96 to FY98 and the ergonomic interventions implemented.

| Trade | 1996 Rank | 1997 Rank | 1998 Rank | Interventions |
|---|---|---|---|---|
| Painter | 1 | 5 | 8 | • Material handling machine<br>• Dollies and carts<br>• Wide foot support ladder |
| Investigator | 2 | 24* | 24* | |
| Auto Mechanics | 3 | 24* | 24* | • Lift tables<br>• Vehicle access ladder<br>• Creepers<br>• Tire dunker<br>• Bead breaker |
| HVAC Mechanic | 4 | 3 | 14 | • Tool back-pack<br>• Portable lift |
| Rigger | 5 | 6 | 10 | • Cable cleaning and lubrication device |
| Carpenter | 6 | 1 | 7 | • Ergonomic tools<br>• Office furniture |
| Insulator | 7 | 23 | 16 | |
| Vehicle Operator | 8 | 20 | 12 | • Air ride bus seats |
| Plumber | 9 | 10 | 24* | • Boom/crane truck<br>• Ergonomic tools (saws)<br>• Knee pads |
| Mason | 10 | 19 | 24* | |

* Indicates that there were no costs for this trade during the year. These –0– costs trades were "tied" for final position.

## Results Discussion

Three major goals were set for the PWC San Diego ergonomics pilot project:

1. improve worker health, safety and quality of life
2. increase PWC efficiency
3. Reduce injury and illness costs.

### Goal 1: Improve Worker Health, Safety and Quality of Life.

Incident and severity rates were used to measure safety and health improvements. Employee comfort surveys were used to measure quality of life improvements.

Quality of life was a challenging goal to measure since it is a very subjective parameter. It may affect a number of measurable factors including: productivity, effectiveness,

retention, safety, and morale. The pilot program used surveys to measure worker discomfort perceived by them conducting specific tasks.

Discomfort surveys were distributed to targeted trade personnel prior to, and after, ergonomic interventions were implemented. The surveys required each worker to grade the amount of discomfort experienced at specific areas of the body. The survey form used is provided as figure 1. A t-test and analysis of variance was conducted to validate the pre and post intervention survey data for 19 work groups that had conducted specific tasks. Post intervention discomfort reduction indicated the following ranges:

- Neck discomfort – 10 to 35 percent reduction
- Back discomfort – 29 to 70 percent reduction
- Upper extremity – 16 to 40 percent reduction
- Lower extremity – 18 to 37 percent reduction

In the more generalized areas of work difficulty, energy levels, and job satisfaction, the results were very subjective on the part of workers completing the survey. Employee reactions to the question, “How hard do you work?” was fairly consistent, with a reduction, on average, of 10%. Employees rated their job satisfaction 13% higher after ergonomic interventions were implemented. Finally, PWC employees enjoyed an average of 26% more after-work energy as a result of ergonomic interventions.

Interpretation of post intervention results should be done with caution since the subjective grading by these workers could have been biased by their knowledge that an intervention to improve job performance and decrease discomfort had been applied in the workplace.

## Reduction of WMSD Cases

During 1996, a total of 86 WMSDs were reported. The number of WMSD cases within the ten targeted trades was reduced by 63% by the end of the pilot program. The total number of WMSD cases for all trades fell 55% during the pilot program. Table A illustrates the reductions in WMSD cases from FY96 through FY98.

**Table A**
**Number of WMSD Cases**

| | FY96 | FY97 | FY98 |
|---|---|---|---|
| Targeted Trades | 38 | 26 | 14 |
| Other Trades | 48 | 55 | 25 |
| Total New WMSD Cases | 86 | 81 | 39 |

## Lost Workday Reduction

Table B illustrates a 70 percent reduction in WMSD related lost workdays during the study period. The targeted trades experienced a lost workday reduction of 95% and by program's end accounted for only 9% of the command's total lost workday experience.

**Table B**
**Lost Workdays**

| | FY96 | FY97 | FY98 |
|---|---|---|---|
| Targeted Trades | 115 | 104 | 6 |
| Other Trades | 110 | 85 | 62 |
| Total Lost Workdays | 225 | 189 | 68 |

Case management information indicated that in 1996, six incidents resulting in 34 lost workdays occurred in the carpenter trade. In 1997, the number of incidents dropped to four. However, the cases were more severe resulting in approximately 75 lost workdays. Two incidents of back strain alone accounted for 59 lost workdays. In FY98, there were three incidents for carpenters, but the severity was extremely low, resulting in only two

lost workdays for the entire year. By the end of the pilot program, both the incident and severity rates of carpenters WMSD had declined.

The documented reduction in WMSD cases and related lost workdays in the targeted trades demonstrates the benefits and effectiveness of ergonomic intervention and training.

## Goal 2: Increase PWC Efficiency

Efficiency productivity metrics were the reduction in labor requirements and the reduction in the number of WMSD related lost workdays. Increased efficiency due to ergonomic intervention is best exemplified by the following examples:

- **Crane Cable Cleaner/Lubricator**. By far the most impressive savings in labor cost avoidance was for the crane cable cleaner/lubricator. This tool was purchased by PWC San Diego late in 1997, more than halfway through the pilot program. The labor cost avoidance is considered conservative because overtime pay was not considered and the hourly wage of $13.25 was a low estimate. Additional savings considering the reduction of consumables was not included either.

- **Pneumatic Tire Bead Breaker**. The pneumatic bead breaker permitted 812 hours of labor to be redirected to another work process. The bead breaker proved to be so successful and popular with the auto maintenance shop personnel that two more were eventually purchased.

- **Automatic Tire Dunker**. The automatic tire dunker saved PWC San Diego auto mechanics 2,500 hours of labor.

These three ergonomic interventions resulted in a total labor savings of 14,745 labor hours. Table D provides a description of the productivity gains and cost avoidance resulting from the three ergonomic interventions.

## Table C
## Summary of Productivity Gains from the Evaluated Ergonomic Interventions

| Intervention | Annual Labor Hours Before | Annual Labor Hours After | Annual Labor Hours Reduced | Labor $/Hr | Annual $ Avoided/ Equipment | Number Purchased | Total $ Annual Cost Reduction |
|---|---|---|---|---|---|---|---|
| Cable Cleaner/ Lubricator | 14,592 | 1,368 | 13,224 | $13.25 | $175,218 | 1 | $175,218 |
| Tire Bead Breaker | 354 | 83 | 271 | 13.25 | 3,591 | 3 | 10,772 |
| Tire Dunker | 1,500 | 250 | 1,250 | 13.25 | 16,562 | 2 | 33,124 |
| Totals Annual | 16,446 | 1,701 | 14,745 | | $195,371 | | $219,115 |

### Ratio of Productivity Benefits to Purchase Price for Interventions

Table E illustrates the cost avoidance ratio to investment cost. A number greater than 1 indicates that the cost of the product is at least paid back within the product's life cycle due to reduced labor requirements. The payback period is the length of time an intervention requires before benefits have equaled purchase and operating costs. The automatic tire dunker payback period was 69 days, the tire bead breaker payback period was 111 days, and the cable cleaner/ lubricator payback period was 10.5 days

## Table E
## Ratio of Productivity Dollars Avoided to Purchase Price for Ergonomic Interventions

| Intervention | Purchase Price | Dollars Avoided Through Increased Productivity | Ratio |
|---|---|---|---|
| Cable Cleaner/ Lubricator | $1,090 | $175,218 | 161 |
| Tire Bead Breaker | $1,095 | $ 3,591 | 10 |
| Tire Dunker | $2,990 | $ 16,562 | 11 |

## Goal 3: Reducing Injury and Illness Costs

Workers Compensation data is a direct measure of occupational injury and illness cost. Compensation costs include FECA costs, all associated medical costs, plus the cost for continuation of pay for up to 45 days of an employee's disability.

During the pilot program's first year, total compensation costs rose 24% due to an increase in carpenter trade WMSD. By the end of the second year, compensation costs decreased 74% from $98,821 to $25,716.

Table F details both the overall worker compensation related costs and that of the targeted trades. The targeted trades faired very well during the pilot program, dropping from 76% of the total compensation related costs in FY96 to only 52% in FY97, and finally to only 10% in FY98.

**Table F**
**Summary of the WC-Related Costs**

| | FY96 | FY97 | FY98 |
|---|---|---|---|
| Targeted Trades (percent of total WC) | $75,221 (76%) | $63,784 (52%) | $2,454 (10%) |
| Other Trades | 23,600 (24%) | 58,443 (48%) | 23,262 (90%) |
| Total compensation Costs | $98,821 | $122,227 | $25,716 |

## Return on Investment Analysis

Appendix C provides guidance to calculate a Return On Investment. The following are elements of the ROI germane to the study:

A. The study return on investment uses two separate scenarios or options for comparison purposes:

- **Program Option:** Results represent conditions that actually occurred as a result of the implementation of the pilot program.
- **Without Program Option:** Results represent conditions that would have resulted had the pilot program NOT been implemented.

**B**. **Baseline and program years.** Baseline years refer to any years prior to FY97. Program years refer to the 2 years of the pilot program, FY97 and FY98.

**C**. **Results for projected "out years".** For purposes of projecting future savings, the ROI includes a number of calculations that project results beyond the end of the program years. These are the projected "out years".

**D**. **Payback period.** The payback period is the point at which the pilot program has "paid back" its own cost with benefits.

**E. Savings to Investment Ratio (SIR).** SIR is a method to determine if the investment is justified by the savings it generates. A number less than one indicates that the savings does not equal the investment required to generate it. A number greater than one indicates that the investment is justified by the savings it generates. The higher the number, the greater the savings relative to the investment.

## Costs Considered for (ROI)

The following are cost considerations included in the ROI:

- Worker Compensation related costs. Short term and long-term compensation costs as well as associated medical costs and continuation of pay (COP) costs.

- Program Costs. Start-up costs, ergonomic interventions, purchase of new equipment, tools, furniture, building modifications, and the pro-rated portion of the program coordinators salary.

- Productivity savings and cost avoidance. Productivity that is a function only of labor savings is considered cost avoidance. Labor savings were calculated with representative labor rates for employees performing the jobs. Productivity savings associated with reductions in consumables or waste reduction were considered direct savings.

The ROI did not consider the following costs:

- Recurring costs . Cost of maintaining the ergonomic program after the end of the pilot program. The savings that result from the ROI are generated only by the original investment and start-up costs.

- Indirect costs Cost of replacement workers for new employee training and productivity lost to retraining.

- Other cost avoidance. Medical or worker compensation related costs avoided as results of ergonomic interventions.

### 2.1.1 ROI Assumptions

The following assumptions were made with regard to the ROI:

- "Without Program" data reflects Navy-wide trends.
  Navy-wide FECA compensation charge back data was used to project the "Without Program" cost data for 1999-2006. The assumption is that without the pilot program worker compensation costs at PWC San Diego would change at approximately the same rate as Navy-wide costs.

- "With Program" costs for 1999-2006 remain constant at FY98 level.
  The "With Program" scenario assumes worker compensation costs will remain constant for the years 1999-2006. These projected costs are adjusted for inflation only. Since only two years of data exist, a reliable trend in the scenario data could not be extrapolated for future projections. In reality, future costs are likely to decline as the program initiatives continue to reduce ergonomic costs.

- All ergonomic interventions implemented through the program maintain or increase productivity
  The assumption is that all ergonomic interventions, not just the three for which calculations were conducted, either maintain or increase productivity while at the same time reducing the risk of ergonomic injuries/illnesses.

## ROI Results

The following results are the comparison of WC-related costs for the Program Option and Without Program option; the payback period; and the savings to investment ratio.

### Workers' Compensation-Related Costs Comparison

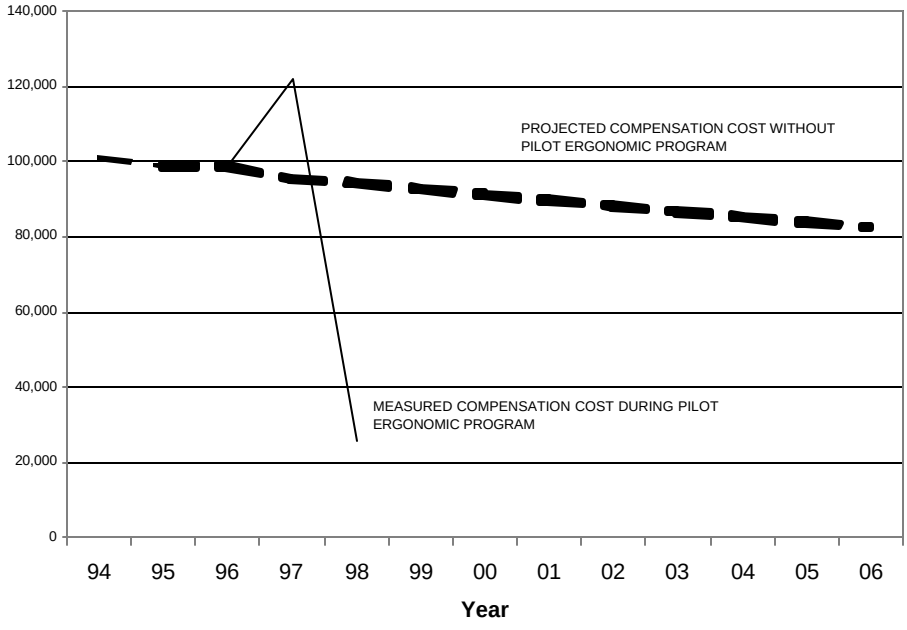
Since the "Without Program" scenario theorizes a situation where the pilot program had not been implemented, the values for worker compensation related costs for the years FY97 – FY06 are theoretical.

Values for the "Program Option" reflect the results for worker compensation related costs that actually occurred for the program years. The values for FY99 – FY06 are

projected. The calculations used to generate these figures do not consider program costs.

Figure 2 describes a significant rise in worker compensation costs in the first year and a reduction in costs at the end of the second year. Relative to the Without Program option, the Program Option yields greater benefit than the 1.67% decrease that Navy-wide trends in worker compensation costs would produce. The Without Program hypothetical option yielded a systematic reduction for both FY97 and FY98, resulting in a theoretical value in worker compensation costs of $94,417 (reduction of 4.46%) by the end of FY98. The actual value for WC-related costs at the end of the pilot program was $25,716, representing a 74% decrease in worker compensation costs.

**Figure 2 – Workers' Compensation Costs**




## Overall Return on Investment

Figure 3 summarizes the overall ROI results. These figures consider all program costs, including start-up investments and all costs of implementing, operating and maintaining the ergonomics program during the pilot program years. These values also include benefits derived from the pilot program for the Program Option scenario.

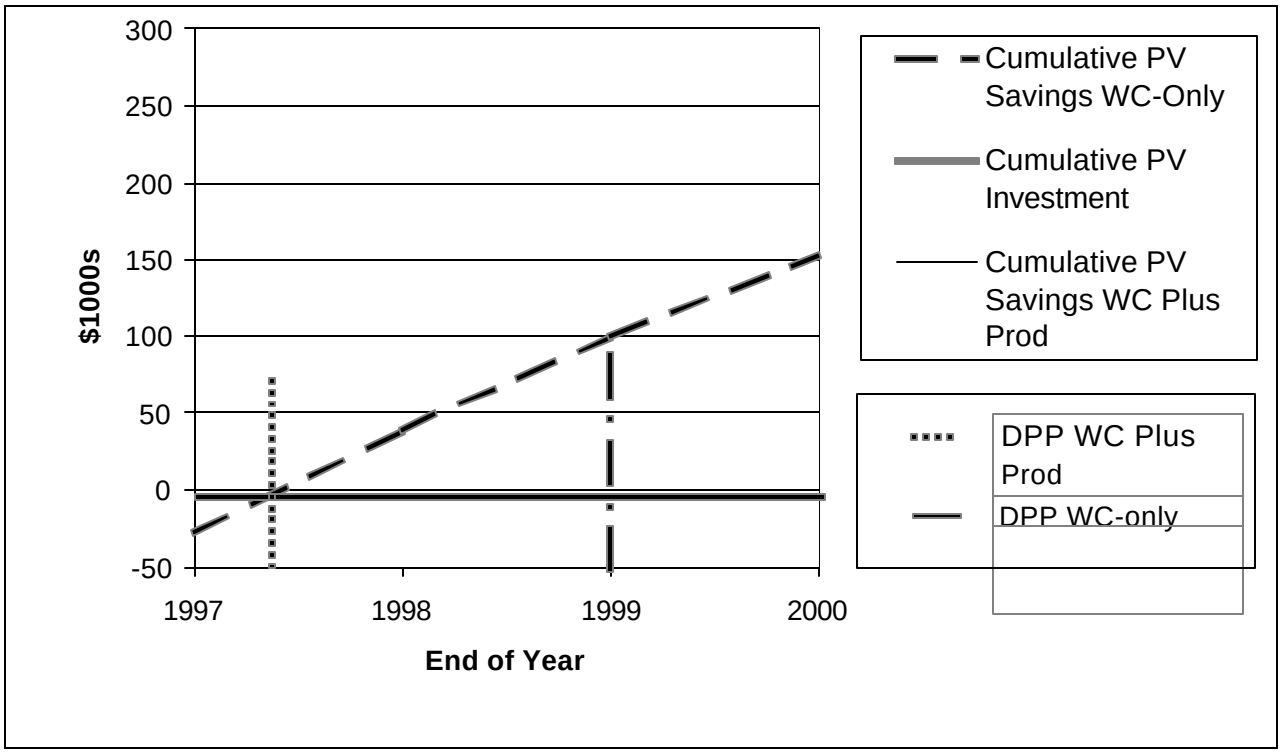
Because the first year of the pilot program could not benefit from the cost avoidance of reduced labor productivity, Program Options costs for FY97 are higher than Without Program costs. Other factors responsible for higher cost was FY97 had increased worker compensation costs and program start-up investment dollars. Year two of the program benefited from the cost avoidance of labor reductions, substantially reduced compensation costs, and a much lower start-up investment contribution. Consequently,

year two of the program saved a remarkable 230% over that of the first year compared to a reduction of only 0.96% for the Without Program option.

## Payback Period

The payback period is the point at which the program pays for itself. Any gains beyond the payback period are considered net savings. Figure 3 shows the payback period to be where the trend line crosses the cost axis on graph. This is the point at which the program produces enough savings to at least pay for its own cost. For points beyond those appearing in “negative territory”, the program has saved money for PWC San Diego. The payback period occurred early in year 2 of the pilot program.

**Figure 3 - Payback Period**



## Savings to Investment Ratio

Table G summarizes the Savings to Investment (SIR) results. The SIR is a calculation that determines the relative value of an investment.

**Table G**
**Savings to Investment Ratio**

| | Program Years FY97 – FY98 | Out Years |
|---|---|---|
| Savings to Investment Ratio (SIR) | 3.42 | 13.76 |

During the program years, for every dollar invested in the pilot ergonomics program, $3.42 was returned in the form of savings or cost avoidance. For every dollar invested in the program for 1997 the predicted return is $13.76 for all of the years through 2006.

## Lessons Learned

This section of the report is dedicated to chronicling some lessons learned from the pilot program at PWC San Diego. The success of the pilot program at PWC San Diego was due largely to strong command leadership, commitment and participation.

### 1. **Training**

Training is more than just teaching workers about body mechanics. The training that the personnel at PWC San Diego received provided practical and useful examples of work process changes that had immediate and positive affects. This training encouraged workers to recognize ergonomic problems and provide solutions.

Training workers to recognize ergonomic related injury potential and management training geared toward understanding ergonomic risk proved to be a key component of PWC's documented successes. Once ergonomic risk was identified by the work force, management's understanding of the issue allowed the chain of command to formulate strategies to resource, document and implement effective interventions.

### 2. Data Collection

Current data collection methods throughout the Navy do not collect data relating directly to WMSDs. The data collection process set up at PWC San Diego was unique and designed to measure effectiveness of applied interventions. Commands wishing to demonstrate the effectiveness of ergonomic interventions must establish measures of effectiveness relative to the intervention, determine a baseline, and then track measures

to determine intervention effectiveness. There may be multiple data sources that require coordination with other commands and organizations.

All metrics and reporting requirements should be established prior to applying interventions. This allows establishment of a good baseline and to also consider data quality and any potential confounding variables. If possible, baselines should be established with data from the previous 3 to 5 years. The analysis of pre-baseline data should also account for significant fluctuations or dramatic changes that may have occurred.

To minimize uncertainty, data types, sources, and reporting should remain consistent throughout the study period. Periodic monitoring of metrics during the study period is essential to determine whether interventions need adjustment or are negatively affecting performance and production. Comparisons of different populations or interventions must use identical metrics.

Worker compensation data, injury and illness data, productivity data, and discomfort surveys proved to be valuable measures in demonstrating the short term positive effects of ergonomic interventions.

The pilot study was conducted over a two year period. It is recognized this period may not be fully sufficient to accurately discern an intervention's impact on those musculoskeletal disorders in the worker compensation system that may take a number of years to develop. It is also recognized that productivity, attitude, and quality of life perceptions may be influenced in the short term by novel work place changes. Longer term trending of illness and injury data would be needed to address these issues.

One drawback of the pilot study was an inability to account for any confounding variables or outside influences that may have affected raw data. For instance, better management of the worker compensation program could also lead to decreasing worker compensation costs. Improved medical management of cases could also lead to decreasing costs. Administrative and managerial changes within the command could influence productivity and subjective complaints of workers. Commands following the pilot study model should account for any outside influences that may affect the data being collected.

Return On Investment and other financial analysis is best done by comptrollers and financial analysts. It is highly recommended all cost benefit analysis, cost related metrics development, issues of productivity, monetary projections, and interpretation of results include an appropriate financial expert.

## 3. Employee Participation

The employees involved in the pilot study participated in evaluating their worksites for improvements, making their work processes more efficient, and teaching others about

ergonomic principles. Consequently, this is a program that evolves on its own with little management influence to keep it going.

# 3. Conclusions

## Goals Accomplished

The goals of this report were to demonstrate the ergonomic pilot program:

- Improved worker health, safety, and quality of life
- Increased productivity by PWC personnel
- Reduced cost by reducing injury and illness

This report provides evidence that the goals of the pilot program were accomplished by the end of FY 98.

- The number of WMSD incidents fell 55%
- The number of lost workdays fell 70%
- PWC workers had saved 14,745 labor hours and $219,115 from only 3 ergonomic interventions
- WC-related costs fell 74%
- The program realized a net savings of $250,657
- The payback period occurred in less than one year
- The savings to investment ratio was 3.42

## Successful Program

The PWC San Diego ergonomic pilot program effectively accomplished its goals and is considered a success. The program continues to operate effectively two years after the completion of the initial pilot program.

## Navy-Wide Application

The concept of work teams assisting management in recognizing ergonomic related problems and recognizing cost effective solutions has Navy-wide application. This report provides examples of management tools that may be applied to reduce worker compensation costs due to musculoskeletal injury experienced in the work environment. These tools may also increase worker productivity or decrease production costs.

## Regulatory Aspects

Currently, there is no Federal regulatory mandate for implementing an ergonomics program either at the command or the Navy-wide level. Occupational Safety and Health Administration (OSHA) ergonomic citations to the industrial sector are generally written under the "General Duty Clause" for failing to provide a safe work environment. Due to the severity of ergonomic injury and its measured impact on worker health, OSHA has proposed a performance-based ergonomics standard for general industry.

Ergonomic related injuries are often the result of years of inadequate work practices or workplace design. Prevention of ergonomic related injury requires commands to recognize ergonomic risk factors in work practices and workplace design. OPNAVINST 5100.23, chapter 23 provides basic program guidance for each command to implement.

*APPENDIX A*

# Ergonomics Program Methodology

## First Steps

This section details the methodology for initiating, implementing and executing an ergonomic program. These steps could be used as a process for implementing an ergonomics program at any command.

## Buy-in from the Command Executive Steering Committee

The ESC accepted the mission for PWC San Diego to participate as a NCEP pilot site. The ESC received one hour of familiarization ergonomics training in addition to a Corporate Ergonomics Program brief.

The ESC appointed an ergonomics coordinator (EC) to ensure successful implementation of the pilot program. The responsibilities of the EC were to select and direct the ergonomic teams (ET), make decisions on intervention implementation, oversee data collection, and report the progress and program status the PWC San Diego ESC and NCEP program manager.

## Selection of the Ergonomics Team and Task Force

The EC selected ET members from a pool of volunteers. The teams were composed of PWC workers representing many different trades and positions. There was an ET for each of the four geographic zones at PWC San Diego. The goal was to keep membership in each ET consistent in size, duties and training. In reality, the size and makeup of each team fluctuated from time to time.

In addition to the ETs, an ergonomics task force was formed. The task force was composed of support personnel such as Human Resources, medical, industrial hygiene, engineering, comptroller, Injury Compensation Program Administrator (ICPA), safety, and supply personnel. The task force did not direct policy or make program decisions, but, provided support to the EC and ETs whenever needed. Support was often in the form of coordinating schedules, providing command briefs and assisting in publicizing and encouraging the pilot program. The task force also used the ergonomic training and awareness they received in the execution of their daily duties.

Ergonomic Team and Task Force Training

The ETs and task force received an initial 40 hours of training in ergonomics by the management team. The major training topics were :

- Practical Principles of Ergonomics
- Team Concepts
- Creating Positive Change
- Musculoskeletal Disorders
- Over-Exertion Injuries
- Cumulative Trauma Injuries
- Ergonomic Risk Factors
- Physiological Issues
- Introduction to Anthropometry
- Effects of Immobilization
- Control Spinal Disorders
- Whole Body Vibration
- Body Mechanics and Lifting
- Physiology of Isometric and Isotonic Work
- Seated Injuries/Office Ergonomics
- Standing Work Injuries
- Ergonomics of the Upper Extremity
- Ergonomics of the Lower Extremity
- Ergonomic Job Analysis
- Train the Trainer
- Healthy Lifestyles

**Pilot Program Charter**

An ergonomics program charter was created and approved by the ESC. The charter included:

- Mission Statement
- PWC San Diego pilot program goals
- Strategy for accomplishing the PWC San Diego pilot program goals
- Standard Operating Procedures (SOPs) for the EC, task force, and team members
- Procedures for conducting ergonomics worksite evaluations and interventions

In addition to the charter, the ESC approved a special budget for the ergonomics pilot program. This budget covered the cost of operating and maintaining the pilot

program to include researching, purchase, and installation of all ergonomic interventions.

## Metrics Established

Metrics were established that would be used for evaluating the progress and effectiveness of the PWC San Diego ergonomics pilot program. Metrics for the program were:

A. Number of WMSD cases**.** WMSDs do not include traumatic ergonomic injuries. This information was recorded by the safety office with assistance from the medical department.

B. Injury Severity resulting from WMSDs**.** The severity of an injury or illness was determined by the resulting loss in work time or lost workdays as recorded by the HRO. The following categories were used to define WMSD severity:

- **First Aid Case**. A non-fatal injury or occupational illness or disease that requires one or more visits to a medical facility for examination or treatment during on-duty hours beyond the day of injury. No medical expense is incurred and no leave or continuation of pay (COP) is charged to the employee.

- **Limited Duty**. A temporary working status in which an employee is used at less than the full range of performance required in the position within any physical limitations prescribed by a Medical Officer or the employee's personal physician.

- **Lost Workday Case**. An occupational injury or disease which prevents an employee from performing work for a full shift on any day subsequent to the day of an injury.

- **No Lost Workday Case**. An occupational injury or disease which does not prevent a civilian employee of the Navy from performing work for a full shift.

- **Total dollars paid for WC-related WMSDs per fiscal year.** WC-related WMSDs includes FECA medical costs and continuation of pay costs. FECA costs consist of medical and compensation costs after the first 45 days of an employee disability. This information was recorded jointly by the HRO and medical department.

C. Information from medical logs that would identify the specific body part affected by the WMSD during the fiscal year. This information was provided by the medical department.

D. Total number of hours worked by PWC San Diego personnel, per fiscal year. This information was tracked and recorded by the HRO.

E. The data collected at PWC San Diego was limited solely to WMSD injuries and illnesses**.** The metrics were carefully compiled to include only this data.

**Preliminary Analysis of PWC San Diego Mishap and Workers' Compensation-Related WMSD Costs**

The EC made an initial analysis of the historical PWC San Diego mishap and FECA data to determine the most effective course of action for ergonomic worksite evaluations. Since PWC San Diego has such a diverse workforce, it was determined that the ergonomic evaluations would be based on trade rather than worksite. The criteria for selecting specific trades for evaluation were:

- High illness and injury rates
- High number of employee lost workdays
- High compensation costs
- High worker complaints
- High employee absenteeism

PWC San Diego employed between 2400 and 2600 workers during the years of the pilot program, representing over 60 trades and positions. The work environments ranged from heavy industrial to administrative work. Each trade had its own unique set of ergonomic hazards.

The Long term nature of employment at PWC San Diego was also considered. The average age of a PWC worker was 46 years and many had worked in the same trade for over 20 years. The long-term exposure to high levels of ergonomic hazards lead to discomfort and pain for some workers and permanent disability for others.

Surveys were collected to characterize worksites and to assess which trades were causing employees to experience high incidences of discomfort. These surveys were general in nature and did not require employee names. The surveys asked the employees to describe their jobs according to personal discomfort, job satisfaction, and and energy levels experienced when the work shift ended. This information addressed both physical discomfort and quality of life issues.

Using the criteria described earlier, and the information obtained in the preliminary discomfort surveys, the following list of trades, in descending order of severity, were identified as those with the highest compensation/lost workday costs, the greatest discomfort causal factors, and/or greatest worker dissatisfaction :

- Painter
- Investigator
- Auto Mechanic
- HVAC Mechanic
- Rigger
- Carpenter
- Insulator
- Motor Vehicle Operator
- Mason

These ten trades, along with other worksites independently identified by the EC or ETs, were targeted as the highest priority trades for receiving worksite ergonomic evaluation. Worksite ergonomic hazard evaluations were prioritized using the following indicators:

- The worksites that met the criteria for high risk trades received the highest priority

- Worksites that had high incidence of discomfort were given the next priority

- All worksites not rated as having high risk indicators or high incidents of discomfort received ergonomic evaluation as time permitted

Eventually, this worksite evaluation process would encompass all PWC San Diego worksites. This process permitted effective distribution of limited resources to those worksites with the greatest need or hazard potential.

## The Pilot Program Begins Ergonomic Evaluations

With the evaluation process defined, and a prioritized list of trades, the teams were ready to begin worksite evaluations. The EC made decisions regarding which worksites were evaluated first, using the prioritization criteria and requests from workcenter supervisors. The ETs began worksite evaluations, at the direction of the EC.

## The Worksite Evaluation Process

The following methods were used to evaluate worksites:

- Observation. The ETs observed the work processes at the worksite. The ETs looked for improper use or modification of tools by the employee, any modification to standard operating procedures (SOP), and any obvious safety hazards.

- Interview. The ETs conducted interviews with the employees at the worksite. These interviews discussed factors that affected the work process, such as variations due to seasonal changes, time of day or night, or different choices

of tools. The interviewer would ask workers what types of changes they would make to work process, schedules, tool and equipment changes. Employees were also asked about any discomfort levels they were experiencing and for recommendations that would lead to improved safety, comfort or productivity/quality of work.

- Discomfort surveys. The ETs conducted detailed, employee specific preliminary discomfort surveys. These surveys required the employee to evaluate physical comfort, perception of exertion, post work energy levels and job satisfaction. The completed surveys provided baseline discomfort level information.

- Specific task analyses. The ETs analyzed the specific work processes based on the training provided by the management team. The following mechanics and risk factors were examined :

  - Awkward or sustained position
  - Excessive force
  - Excessive repetition
  - Contact stress
  - Temperature/environmental extremes
  - Physical conditioning
  - Psychosocial issues, psychologic stress, or low morale
  - Hand-arm or whole body vibration

Recommendations on work processes, postures, or tool choice were often implemented on-the-spot and at no cost to the command. No cost and low cost interventions were very common, and many of these interventions were not officially documented due to their number and frequency. These on-the-spot interventions included equipment adjustments, work practice recommendations, improved work posture, and realignment of tools and equipment. Equipment realignment was common for computer work stations where the vast majority of employees had inappropriate chair positions, monitor placement, or keyboard and mouse alignment. In situations where interventions could not be accomplished immediately abatement decisions were prioritized and performed accordingly.

After thorough worksite evaluations, the EC, ETs, and members of the task force researched potential interventions. A number of considerations were included in the decision to implement an ergonomic intervention:

- **Reengineering**. Will any worksite reengineering be required? Were new tools, worksite modifications, mechanical changes required?

- **Cost**. What would be the cost of the intervention?

- **Time**. How long will the intervention take to implement?

- **Number of affected persons**. How many employees would benefit from the intervention?

- **Others affected**. Will the intervention negatively impact any other employees or introduce a new hazard into the worksite?

The EC would make a final decision on intervention after full consideration of all options and criteria.

**Implementation of the Ergonomic Interventions**

An intervention would be researched when a work process was evaluated and found to be an ergonomic hazard. The EC, ETs and employees would research replacement tools, equipment, or workspace modifications to ensure that the proposed intervention or engineering control would reduce or eliminate the ergonomic hazard without introducing a new hazard. Once an intervention was researched and found feasible the intervention was implemented. The cost of the ergonomic intervention was charged to a special line of accounting which had been approved and allocated by the ESC.

Follow-up worksite evaluations were conducted shortly after the ergonomic intervention was implemented. It was recommended that the follow-up evaluation be conducted from two weeks to two months after the implementation. The purpose of the follow-up visits was to:

- Determine and document any reductions in employee discomfort.

- To ensure that the intervention had been successful in reducing or eliminating the ergonomic hazard and had increased productivity or quality of work.

- To evaluate the success of the intervention and to ensure that no new hazards had been introduced as a result of the intervention

PWC San Diego personnel received one hour of training on basic ergonomic principles. This training covered the following topics:

- Definition of ergonomics – what it means to the worker

- Fundamental body mechanics – as it relates to the specific worker

- How to recognize early warning signs of ergonomic injuries

- How to report and/or request assistance for a thorough ergonomic worksite evaluation

- How to use exercise to control excessive fatigue and injury

- How a healthy lifestyle can reduce the risk of injury/illness

At the conclusion of the 2-year pilot program, 90% of all PWC San Diego workers had received ergonomic training.

## Reporting the Status of the PWC San Diego Pilot Program

The ESC received quarterly status and progress reports through the chain of command. The report contained information on the implemented interventions, budget summaries, employee reactions to the program, program improvement suggestions, and feedback from the program manager.

In addition to the quarterly status report to the ESC, the EC reported the program status to the management team. Whenever possible, the management team made personal visits to assist the EC with improving the program, to conduct additional training, and to evaluate the status of the program.

The NCEP program manager reported the status of all of the NCEP pilot sites to the NAVOSH Quality Council.

## Promoting the PWC San Diego Pilot program

Support for the program required publicizing the benefits and successes of the ergonomics program. The EC periodically wrote articles for the local publication, Centerline, and provided the management team with case studies and testimonials for publication at higher echelon venues.

The EC assigned a dedicated phone line for PWC personnel to report any early signs of musculoskeletal discomfort or to request a worksite evaluation. The ETs responded to these call-in requests based on the apparent risk. The “hotline” was very popular with PWC personnel, as it permitted them to report concerns and problems if an ET member was not immediately available. Many ergonomic interventions were accomplished as a result of the ergonomic “hotline”.

As a result of the publicity and promotion that the program received, the EC had many new ergonomic team recruits to replace lost members due to attrition or changes in work responsibilities. Fortunately, new, enthusiastic and energized team members were the life’s blood of the program, so the dynamic nature of the teams usually were not affected by the membership changes.

*APPENDIX B*

# TIRE BEAD BREAKER

**BACKROUND:** The Public Works Center (PWC), San Diego has shop equipment used to break tire beads for all different sized equipment. They now have a specialty piece of equipment to break tire beads in the field. On average, the beads of four tires ranging in size from 18 inch car tires, to 6 foot heavy equipment tires, need to be broken in the field each day at this facility. The savings recognized by using the automated process are largely dependent on how busy the work schedule is at a given facility.

**MANUAL PROCESS:** The manual bead breaking process involves about 20 minutes of difficult labor for each tire requiring a bead be broken on each side of the tire. The worker swings a large duck-bill hammer repeatedly until the bead is broken. The time involved in just breaking the bead of a tire can vary depending on the size and condition of the tire, since heavily rusted rims and tires with thicker sidewalls involve more time. This process also requires that large tractor tires be removed from the vehicle and manually placed on the ground in order to break the bead with the hammer. For the purpose of this ROI analysis the time estimated for complete tire removal, breaking the bead, and replacement of a tire was 20 minutes for most tires and 30 minutes for heavy equipment tires.

**AUTOMATED PROCESS:** The automated process involves the use of a portable hand held pneumatic bead breaker. The bead breaker is used to break both beads and separate the tire from the rim on a wide variety of tire types. This device reduces the bead breaking time by up to 50% down to 5 minutes per tire in average situations. The tool ultimately reduces the number of time consuming and stressful physical steps in the tire repair process, thereby, reducing the overall risk of injury associated with this task. On average, using the automated process reduces the bead breaking process of 4 tires by 65 minutes.

**COST ANALYSIS SUMMARY:**

| | |
|---|---|
| Manual Process Annual Costs | $ 4,692.71 |
| Automated Process using the Cleaning/Lubricating Tool (Annual Costs) | $ 1,104.17 |
| Annual Cost Difference (Savings) | $ 3,588.54 |
| Tool Purchase Price | $ 1,095.00 |
| Expected Tool Service Life | 20 years |
| Return on Investment (per 20-year period) | |
| • Cost Savings | $ 70,675.80 |
| • Cost Savings Net Present Value | $ 52,593.46 |
| • Break Even Point | 0.305 years or 111.4 days |

*APPENDIX C*

# CABLE CLEANING/LUBRICATING TOOL

**BACKGROUND**: There are 38 separate crane and crane operations within the jurisdiction of the Public Works Center, San Diego. The average crane maintains approximately ½ mile of cable for routine operations. All crane cables must be cleaned and lubricated quarterly for routine maintenance or on an emergency basis should the cables be found defective or break.

**MANUAL PROCESS**: The manual process required 6 workers and 2 full days to complete the cleaning and lubrication of a set of crane cables. Because of the need to have the crane operating at full capacity during normal working hours, maintenance was performed during other-than-normal working hours requiring overtime pay for the civilian work force. The workers cleaned the cables by hand using a wire brush and 2190-type lube oil. Only the outside of the cables were cleaned because accessing the interior of the cables was impossible. Lubrication was then accomplished manually using grease and rags.

**AUTOMATED PROCESS USING THE CABLE CLEANING/LUBRICATING TOOL**: The process for cleaning and lubricating crane cables using the cleaning/lubricating tool involved 3 workers for 4 hours. The crane cables are guided through the grooved plates of the cleaning/lubricating tool. The cables are automatically cleaned both internally and externally. New grease is applied via a nozzle and pump on the tool.

### 4. COST ANALYSIS SUMMARY

| | | |
|---|---|---|
| Manual Process Annual Costs | $ | 320,420.86 |
| Automated Process using the Cleaning/Lubricating Tool Annual Costs | $ | 34,206.38 |
| Annual Cost Difference (Savings) | $ | 286,214.48 |
| Tool Purchase Price | $ | 8,200.00 |
| Expected Tool Service Life | | 10 years |
| Return on Investment (per 10-year period) | | |
| • Cost Savings | $ | 2,853,944.80 |
| • Cost Savings Net Present Value | $ | 2,255,509.53 |
| • Break Even Point | | 0.029 years or 10.5 days |

10 Yr Cost Savings = 10 (annual cost of manual process) – [Tool purchase price + 10 (annual cost of automated process)]

$2,853,644.80 = 10($320,420.86) – [$8,200 + [10($34,206.38)]

Cost Savings Net Present Value =
Σ {[Cost Savings(1+Inflation Rate)^(Future Yr-Present Yr)]/ [(1+Discount Rate))^(Future Yr- Present Yr)]}
(Inflation Rate = 2.1%, Discount Rate = 4.9%, Present Yr = 1998)

Break Even = Tool purchase price/Annual Cost Savings
0.029 = $8,200/ $366,356.48
0.029 * 365 = 10.5 days

# CABLE CLEANING/LUBRICATING TOOL COSTS

| 4.1.1.1 Manual Cleaning/Lubricating Process | 4.1.1.2 Automated Cleaning/Lubricating Process |
|---|---|
| Consumables<br>Rags:<br>$30/400 rags x 72 rags/crane x 38 cranes x 4 time/year<br>Rags Cost: $820.80/year<br>Grease:<br>$157/5-gal x 5 gal/crane x 38 crane x 4 time/year<br>Grease Cost: $23,864.00/year<br>2190-type Lube Oil<br>$18.60/gal x 20 gal/crane x 38 cranes x 4 time/year<br>Lube Oil Cost: $56,544.00/year | Consumables<br>Rags:<br>$30/400 rags x 12 rags/crane x 38 cranes x 4 time/year<br>Rags Cost: $136.80/year<br>Grease:<br>$157/5-gal x 3.3 gal/crane x 38 crane x 4 time/year<br>Grease Cost: $15,750.24/year<br>2190-type Lube Oil |
| Total Consumables Annual Cost<br>$**81,228.80/year** | Total Consumables Annual Cost<br>$**15,887.04/year** |
| Labor<br>WG-XX rate: $13.25/hr<br>16 hr/crane x 6 persons x 38 cranes x $13.25/hr x 4 time/year | Labor<br>WG-XX rate: $13.25/hr<br>3 hr/crane x 3 persons x 38 cranes x $13.25/hr x 4 time/year |
| Total Labor Cost:<br>$**193,344/year** | Total Labor Cost:<br>$**18,126/year** |
| **4.1.2 Waste Disposal**<br>Rag Disposal Rate: $1.06/lb<br>1 lb/10 rags x 72 rags/crane x 10 rags x $1.06/lb x 38 cranes x 4 time/year<br>Rag Disposal Costs: $1,160.06/year<br>Lube Oil Disposal Rate: $2.10/lb<br>20 gal/crane x 38 cranes x 7lb/gal x $2.10/gal x 4 time/year<br>Lube Oil Disposal Costs: $44,688.00 | ***Waste Disposal***<br>Rag Disposal Rate: $1.06/lb<br>1 lb/10 rags x 12 rags/crane x 10 rags x $1.06/lb x 38 cranes x 4 time/year<br>Rag Disposal Costs: $193.34/year |
| Total Disposal Costs:<br>$**45,848.06/year** | Total Disposal Costs:<br>$**193.34/year** |
| ***Total Annual Costs*** | ***Total Annual Costs*** |

| | |
|---|---|
| Consumables | $ 81,228.80 |
| Labor | 193,344.00 |
| Waste Disposal | 45,848.06 |
| **Total:** | **$320,420.86** |

| | |
|---|---|
| Consumables | $15,887.04 |
| Labor | 18,126.00 |
| Waste Disposal | 193.34 |
| **Total:** | **$34,206.38** |

**APPENDIX D**

# TRUCK TIRE DUNKER TOOL

**BACKGROUND**: Before the Truck Tire Dunker was introduced at San Diego Public Works Center (SDPWC), checking tires for leaks required the combined efforts of 2 workers. Because the tire department had only one fulltime employee, the second worker had to be actively recruited from another work area to provide assistance. This accounts for even more labor time than just lifting the tire in and out of the tank. Aside from the significant increase in required labor for this process the risk of musculoskeletal injury is considered to be very high due to the physical mechanics of this process.

**MANUAL PROCESS:** The manual process involved with this task required the lifting of 239-270 lb mounted tires, one at a time, into a tank of water. The tire then is then rotated and lifted back out of the water by two people. The manual process takes about 30 minutes per tire for each of the two people.

**AUTOMATED PROCESS:** The automated process from start to finish includes the following steps. The tire is rolled onto the ramp directly above a cradle. The tire is lifted by the cradle when the foot valve is actuated and then rotates the tire and lowers it into the tank. The worker inspects the rotating tire for leaks in the water-filled tank. To remove the tire from the tank this process is reversed. Inner-tubes can be checked just as easily.

The process for lifting the tire into the water tank, rotating it, and lifting it back out of the tank while incorporating the use of the tire dunker can be completed by one worker in 10 minutes without significant risk of injury or strain.

**COST ANALYSIS SUMMARY:**

| | |
|---|---|
| Manual Process Annual Costs | $ 19,875.00 |
| Automated Process using the Tire Dunker Tool Annual Costs | $ 3,300.00 |
| Annual Cost Difference (Savings) | $ 16,575.00 |
| Tool Purchase Price | $ 2,990.00 |
| Expected Tool Service Life | 20 years |
| Return on Investment (per 20-year period) | |
| • Cost Savings | $ 328,510.00 |
| • Cost Savings Net Present Value | $ 242,922.40 |
| • Break Even Point | 0.18 years or 65.8 days |